Internet Tools for Sharing Unmanned Vehicle Information

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ABSTRACT

Using Mosaic and other emerging Internet tools, a user at a workstation or personal computer attached to the Internet can find and access multi-media information hosted on server systems anywhere in the world, using an intuitive "point and shoot" interface in a windowed environment. The power of these systems derives from clever structuring of the databases, so that any server can "point" to data hosted by any other server.

This presentation provides a brief introduction to the terminology and user interface paradigms of the World Wide Web, and conveys a feeling of how simple it is to "publish" (as well as access) information in these modes. Evolving DTIC/IAC and other WWW/Gopher resources in robotics and related fields are identified, and the possible roles and implications for the Unmanned Vehicle community of these decentralized, highly distributed public information sharing tools are discussed.

INTRODUCTION

The last year or so has seen the emergence of the Internet into the consciousness of the popular media. A plethora of books and magazines have appeared purporting to initiate the uninitiated and guide the intimidated around the Internet, newspaper columnists regularly describe their adventures on the "Information Superhighway", and Public radio news programs have their own email addresses (and even ftp sites [1]). The number of people with access to Internet email is said to now number in the tens or even hundreds of millions, and to be growing at 80% per year.

This rapid growth is occurring just as a new generation of tools for accessing information is emerging on the Internet. Several "classic" network services date from early ARPANET days (circa 1969): telnet, which allows a terminal (or PC acting as a terminal) connected to a local host computer to behave as if it were directly connected to a distant host; file transfer protocol (ftp), which allows a user to transfer files between a distant host computer and his/her local host; and email. These are now joined by other services with names like the World Wide Web, Mosaic, Gopher, and WAIS. These new tools, sometimes generically termed "network information discovery and retrieval" tools, allow a user to successfully navigate through the intimidating volumes of data on the Internet to retrieve what he/she wants. John Markoff began a December 1993 article in The New York Times: "Think of it [Mosaic] as a map to the buried treasures of the Information Age" [2].

This paper is intended to (1) motivate and help "bootstrap" new Web users; (2) describe current IAC and other Web information resources relevant to Unmanned Vehicles; and

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(3) promote the broad use of Web technology as a powerful and cost-effective means for sharing Unmanned Vehicle information. Since the best vehicle for describing the Web is the Web itself, a hypertext version [3] of this document is available via ftp on the Internet. If you have access to Mosaic or another Web browser, you should certainly read this on line! A text version [4] and a compressed PostScript version [5] of this paper are also available.

WHAT'S GOING ON HERE?

Before we discuss specifics in the next section, let's look at some underlying concepts associated with the emerging tools. Figure 1 depicts some of these points of distinction between the new tools and the "traditional" Internet services.

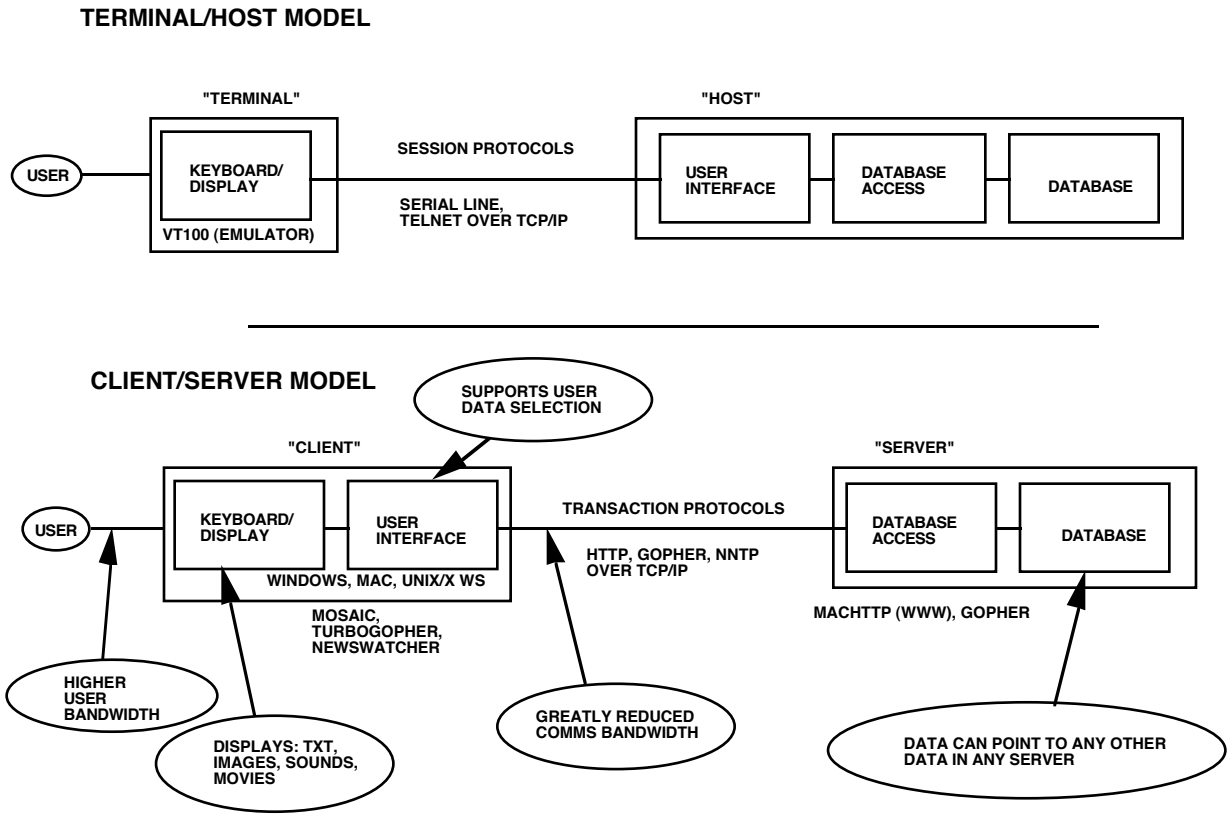

Figure 1. Terminal/Host and Client/Server Network Service Models

Client/Server vs Terminal/Host model. The new tools exploit the computing power now available on the desktop by moving the processing load off the computer that actually provides the data. The client software formats and displays multimedia files and provides an intuitive, consistent graphical interface for the user, organizing retrieved data and keeping track of the user's selections, as well as handling all the work of communicating with the information server. Putting the processing on the desktop increases the information bandwidth provided to the user while reducing the communications bandwidth required over the network.

Transaction-based vs connection-oriented protocols. The interactions between the desktop client and remote information servers take the form of self-contained transactions. The server doesn't have to maintain any state information about the user -- it just handles each independent data request as it arrives.

Standardized Multimedia File Types. A relatively small number of file types are emerging as the standards for images, audio, and video, and applications are becoming available to read these standard file types across the full spectrum of desktop machines.

Coherent User Model. The client software provides a consistent and intuitive model for the exchange of information. Click on an icon or highlighted text string, and a new information page is retrieved and displayed. Click on a menu item or icon and a previously retrieved page is displayed from local memory. Click on a menu item to save the pointer to a data item for future re-retrieval.

Embedded Pointers ("Hypertext"). A page of information can contain pointers to other pages, which can be hosted on servers located anywhere in the world. Click here [6] to see the Mona Lisa direct from the Louvre. Click here [7] to hear Secretary of Commerce Ron Brown outline Administration goals for the National Information Infrastructure. Click here [8] for the latest Detroit weather forecast.

SYSTEMS AND TOOLS

Since numerous guides and descriptions are already available on the Internet, this section will be little more than a brief glossary of terms, plus appropriate pointers.

World Wide Web. "The World Wide Web (W3) is the universe of network-accessible information, an embodiment of human knowledge. It is an initiative started at CERN, now with many participants. It has a body of software, and a set of protocols and conventions. W3 uses hypertext and multimedia techniques to make the web easy for anyone to roam, browse, and contribute to." [9]

Mosaic. World Wide Web client software available free from NCSA for Unix/X, PC/Windows, and Macintosh computers [10]. Because Mosaic provides a user-friendly interface, displays multimedia data (sometimes via "helper applications"), handles the protocols of many different servers (e.g., HTTP, gopher, ftp, telnet, NNTP), and is available via the Internet at no cost, it is a good choice as a tool to bootstrap oneself into "Cyberspace". See "Getting Started" section below.

Gopher. System similar to and intertwined with the Web, developed by the University of Minnesota [11]. Gopher doesn't support hypertext; instead, the user view is based on directory-like menus. Gopher has its own protocol and client and server software for standard platforms, but Mosaic also functions as a client to gopher servers.

WAIS (Wide Area Information System). Full text database indexing system developed by Thinking Machines Corp. The public domain version is called FreeWAIS, of course. Usually a "behind the scenes" resource for Web users.

Archie. Give this utility a file name and it will tell you which anonymous ftp servers can serve the file to you, across the whole Internet [12]. PC and Mac users have to login via telnet to an Archie server; Xarchie provides a client on Unix/X machines.

Veronica. Utility that performs key word searches through nested gopher menus [13].

It may be useful to draw a distinction between the "Net" and the "Web" as follows: the Net is a very large number of computers interconnected by communication links; the Web is a much larger number of data items interconnected by hypertext and other pointers. The Web lives on the Net.

GETTING STARTED AS A WEB/ MOSAIC USER

You can access the Web via a VT100 terminal connected to an Internet host that has Lynx [14] software, but only in text mode.

To get the full benefit of the multimedia information being served on the Web, you need to install a "fully-featured Web Browser" such as Mosaic on your desktop computer. Mosaic is FREE and available via anonymous ftp over the Internet from NCSA, in separate versions for Unix/X machines [15], Windows PCs [16], and the Macintosh [17]. It comes bundled with several freeware and shareware helper applications to display different formats of audio, images, and video files.

To use Mosaic, your computer must have a full TCP/IP connection to the Internet. An Ethernet LAN connection to the Internet provides a good high-bandwidth link, but protocols named SLIP (Serial Link Internet Protocol) or PPP (Point to Point Protocol) also make it possible to use a serial link, either hardwired or via telephone modem. Your organization may support a SLIP or PPP server with dialup ports, or you can subscribe to a public service. Costs vary widely, but could be as little as $20-$30 per month. A list of such dialup services, broken out by telephone area code served, is available on the Net [18]. You may have to buy SLIP, PPP, and/or TCP/IP software for your computer.

SERVING DATA

While the low cost of turning your desktop computer into a Web client should please you, it may not surprise you. What SHOULD surprise you is that you can turn your desktop computer into a Web SERVER for very little beyond the cost of a full time Internet connection (Ethernet, or dedicated serial port, plus leased phone line if needed). Because the complexities of displaying multimedia information and of keeping track of the user's "state" are handled by the client (e.g., Mosaic), all a Web server has to do is to handle the HTTP protocol and send requested files to the client. This means it can be very simple: the the binary for the Macintosh Web server application software (MacHTTP) is about 8% of the size of Microsoft Excel -- and that includes TWO complete versions of the code, one for the new PowerPC as well as one for the Motorola 680x0! MacHTTP has recently become a commercial product, but the maximum price listed in its sliding fee schedule is only $100. Mosaic can also retrieve Web hypertext (HTML) files from an anonymous ftp server, as well as from a Web server.

Besides getting your server up and running, you will need to generate your data files. Writing HTML (that's "HyperText Markup Language" [19]) files is not hard, in fact, several Web servers have been implemented by elementary school students [20]. It is common practice to announce your server while many of its pages are still "under construction". You probably should spend more time and effort up front in planning your server than in its actual initial implementation. What is your target audience? What material do you want to make available to them? Do you want to use images, audio, or video? How? How do you want your audience to respond (e.g., Mosaic 2.0 provides a "forms" capability to capture data from a client)? Browse the Web to see what others have done!

A role is clearly emerging for third party Web servers. Very small organizations may wish to avoid the expense of full-time leased-line connectivity to the Internet, while, for security reasons, some larger organizations use a "firewall" to limit the flow of data between their internal subnet and the rest of the Internet to basic email. And some organizations may simply choose not to be bothered with the day to day tasks of system administration. The role of a third party Web server could vary: from simply serving polished Web pages created by information providers, to implementing individual HTML pages, to handling the complete design of the server. Web design consultants are already making their appearance.

WHAT WILL THE FUTURE BRING?

The World Wide Web is still being born. Explosive growth in Web use has been stimulated by the release of the Windows and Macintosh versions of Mosaic by NCSA in November 1993. Which multimedia data formats should be supported is not yet universally agreed on, and "helper applications" are not yet available on all three platforms for all "standard" formats. Access control and security are primitive. HTTP is clearly the Internet protocol which has gained the widest use before it has even received an official RFC number. The actual Web tools -- protocols and software -- will continue to mature, consolidating functionality, increasing performance, and improving reliability. Moreover, the same hypertext paradigm used in the Web is also being applied to CD-ROM data. Ultimately the same client program should access both local and networked multimedia data in a seamlessly integrated fashion.

The hypertext user model (click on the highlighted text or icon to retrieve the next page) is easy to use because it is so highly intuitive, but it is certainly possible for a Web server to be so poorly organized that the user can not find what he/she needs -- it is especially frustrating to be unable to find information you have found before! As servers proliferate and become widely used, some styles of organizing and presenting information will become established as de facto standards, while others will disappear. Nick Arnett, of Multimedia Computing Corp, has drawn an analogy between current Web builders and the printers and scholars who established the canonical form of printed books in the period following the invention of the printing press and inexpensive paper [21]. A "Best of the Web Awards" has already been initiated [22]!

DTIC and the IACs

DTIC and the IACs are recent entrants who are rapidly expanding their use of the Web and other Internet tools. The DTIC-A HOV-LANE (Hypertext-Online-Virtual Library for Acquisition News and Electronic Information) page [23] provides pointers to (1) the DTIC home page, with on-line versions of both the DTIC "Green and White" informational brochure and the more detailed DTIC Handbook for Users, including information on how to become a registered DGIS user; (2) the IAC directory [24] (providing points of contact and describing the IAC's subject coverage and products and services), with pointers to individual IAC Web pages and Gopher servers being added as they come on line; and (3) the HOV subject guides, currently "under construction", which are organized into two groupings: Subjects, which are broad categories for organizing sources and information, and Types, which are grouped basically by the origin or generic nature of the information.

DTIC-A has recently developed draft home pages for a number of the IACs. The High Temperature Materials Information Analysis Center (HTMIAC) homepage [25] was

unveiled on 6 April, with an online version of the HTMIAC Winter 94 Newsletter. The Data and Analysis Center for Software (DACS) homepage [26] similarly provides access to several issues of the DACS Newsletter. Homepages for the Manufacturing Technology Information Analysis Center (MTIAC) and the Reliability Information Analysis Center (RIAC) are imminent.

Apart from its presence on the Web, DACS also runs the Robotics and Artificial Intelligence Database (RAID) [27], an information source on Department of Defense (DoD) sponsored research projects on artificial intelligence (AI) and robotics. RAID was established in the early 1980's and now contains reports from over 2000 research projects and 3000 points of contact. RAID contains: research project summaries including funding information, points of contact with their appropriate areas of knowledge, a calendar of upcoming conferences and meetings, and summaries of past AI-related conferences. Online Internet access to RAID services is available to Government agencies. Government contractors can order and receive hardcopy reports; written sponsor endorsement and DoD Form 2345 are required.

The Tactical Warfare Simulation & Technology Information Analysis Center (TWSTIAC), together with The Defense Modeling and Simulation Office (DMSO), DTIC), and the Institute for Simulation & Training - University of Central Florida (IST-UCF), provides electronic access to information via the Modeling and Simulation Information System (M&SIS). The TWSTIAC Gopher [28] provides pointers to an array of resources in the areas of modeling and simulation. For example, following a couple of links leads to a catalog [29] of Navy-relevant simulation and modeling tools, with brief descriptions and points of contact. Since this is Gopher based, it is not as user-friendly as a Web system would be (the use of hypertext links would allow Web "browsing" without having to retrieve so many individual files), but it gets the job done.

OTHER UNMANNED VEHICLES/ ROBOTIC RESOURCES

Several very useful starting points for accessing robotic and related information exist on the net: (1) the Robotics Internet Resources Page [30] at the University of Massachusetts and (2) the Computer Vision Home Page [31] at Carnegie Mellon focus principally on university research groups and projects that serve information on the Internet, while (3) the comp.robotics-FAQ Table of Contents [32] at the University of Indiana provides pointers to more diverse robotics resources such as robot clubs and societies around the world, magazines of interest, and component manufacturers.

Non-academic unmanned vehicle efforts are not yet well-represented on the Internet. The ARPA UGV Demo II Project is principally in evidence through the CMU's NavLab Web pages [33], although Martin-Marietta makes Demo II project data available to approved users (associated project participants) through an anonymous ftp server.

OPPORTUNITIES FOR UNMANNED VEHICLE INFORMATION SHARING

On a personal level, the Web is an ideal "networking" medium. Your boss thinks you should visit University X to learn about technology Y? Make your trip more productive and enjoyable by looking at the University's Web Pages to determine that it's Professor A in Department B you should contact, rather than Professor C in Department D, and then familiarize yourself with his/her research and interests before you travel. And be sure to check the weather the evening before you fly.

On an organizational level, the Web is an ideal public relations medium. Your organization can shape a message and serve it (or have it served) on the Internet to a potential audience of millions, at a reasonable cost. Prospects anywhere in the world can glance at your "glossy brochures", then look at the detailed "data sheets" that interest them.

In the Unmanned Vehicle world, it is clear that Web tools can be used to help foster improved communication and coordination between various R&D organizations and projects within the currently well-focused communities of interest such as UGV, UAV, and UUV. Ultimately, however, perhaps larger gains may well accrue from stimulating interactions between different communities whose very similar interests may be obscured by differences in emphasis and terminology. Similarly, international interactions should be greatly facilitated. At this early stage, Canada, Australia, New Zealand, and Europe seem to be more active with Web technologies than is Japan.

DTIC and the IACs could serve any of several important roles in this process: as centralized third party Web servers (certainly to provide at least directory services pointing to other resources), as draft homepage implementers (the role that DTIC-A is now playing for the IACs), or even as Web design consultants. And they could provide encouragement and "handholding" to novice Web users and servers. These roles would be in addition to providing specific technical services for which Web distribution is appropriate.

CONCLUSIONS

A new generation of information discovery and retrieval tools exemplified by the World Wide Web and Mosaic are emerging on the Internet. Because these tools facilitate both accessing and serving data at minimal cost, growth in their use is explosive. Web technology is well suited to the task of improving the level of communication and coordination between various Unmanned Vehicle research and development efforts. DTIC and the IACs can play a valuable role as catalysts. Multimedia Computing's Nick Arnett likes to characterize the situation in the words of the sage Pogo: "We are surrounded by insurmountable opportunity."

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REFERENCES

These references are in the form of Uniform Resource Locators, or URLs. A URL provides a Web client with the information needed to retrieve a specific data item. When you click on a highlighted link in an .html document, Mosaic automatically retrieves an invisible embedded URL pointer. The format of a URL is:

scheme://hostname:port/filepathname.ext

where: *scheme* specifies the protocol the client should use to access the host; examples are http, gopher, ftp, telnet, or file; *hostname* specifies the name or full IP address of the host computer the client should contact; *port* specifies the IP port the connection should be made on (when this is omitted, the default port for the scheme is used, e.g., 80 for HTTP); *filepathname* specifies the complete path name of the desired data item on the host machine (to a first approximation, think of a UNIX

directory structure and name; a server will typically return a default item if this URL element is omitted); and *ext* is a name extension that specifies the type of data item (the client usually checks the extension to determine how to display the item). URLs are not really quite this simple, but this is a good first approximation. See [34] and its links for more details, and look at the URLs below for examples.

NOTE: Some of the URLs below continue onto a second line. Just run the lines together; **a URL contains no spaces**.

1. ftp://ftp.clark.net/pub/watc/watc.html
2. http://www.ugcs.caltech.edu/~kluster/markoff.html
3. ftp://ftp.nosc.mil/pub/telerobotics/papers/auvs94dg.html
4. ftp://ftp.nosc.mil/pub/telerobotics/papers/auvs94dg.txt
5. ftp://ftp.nosc.mil/pub/telerobotics/papers/auvs94dg.ps.Z
6. http://mistral.enst.fr/~pioch/louvre/paintings/vinci/
7. http://sunsite.unc.edu/dykki/snd/brown.au
8. gopher://wx.atmos.uiuc.edu/00/States/Michigan/Metro%20Area%20Zone%20Fcst%20%28Detroit-DTW)
9. http://info.cern.ch/hypertext/WWW/TheProject.html
10. http://www.ncsa.uiuc.edu/SDG/Software/Mosaic/NCSAMosaicHome.html
11. gopher://boombox.micro.umn.edu/11/gopher
12. ftp://archie.ans.net/pub/archie/doc/whatis.archie
13. gopher://gopher.unr.edu/00/veronica/veronica-faq
14. ftp://ftp2.cc.ukans.edu/pub/lynx
15. ftp://ftp.ncsa.uiuc.edu/Mosaic
16. ftp://ftp.ncsa.uiuc.edu/PC/Mosaic
17. ftp://ftp.ncsa.uiuc.edu/Mac/Mosaic
18. ftp://ftp.netcom.com/pub/infodeli/publicaccess/pdial
    OR, send email to info-deli-server@netcom.com, including the line: send PDIAL
19. http://www.ncsa.uiuc.edu/demoweb/html-primer.html
20. http://oops-still-looking-for-this-one!
21. http://198.92.133.3/Mendicants.html
22. http://wings.buffalo.edu/contest/
23. http://asc.dtic.dla.mil:3221/home
24. http://asc.dtic.dla.mil:3221/dtica/iac_dir.html
25. http://asc.dtic.dla.mil:3221/iac/htmiac/htmiachome.html
26. http://asc.dtic.dla.mil:3221/iac/dacs/dacshome.html
27. Send email to dacs-info@kaman.com, including the line: send raid info
28. gopher://yvette.iac.ist.ucf.edu/
29. gopher://dmso.dmso.dtic.dla.mil:4350/11/mnscatalogs/navy
30. http://piglet.cs.umass.edu:4321/robotics.html
31. http://www.cs.cmu.edu:8001/afs/cs/project/cil/ftp/html/vision.html
32. http://cs.indiana.edu/robotics/table.html
33. http://www.cs.cmu.edu:8001/afs/cs.cmu.edu/project/alv/member/www/navlab_home_page.html
34. http://www.ncsa.uiuc.edu/demoweb/url-primer.html